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1. AOP-21 (Edition 1) - FUZING SYSTEMS: MANUAL OF DEVELOPMENT CHARACTERIZATION AND SAFETY TEST METHODS AND PROCEDURES FOR LEAD AND BOOSTER EXPLOSIVE COMPONENTS is a NATO UNCLASSIFIED publication.

2. AOP-21 is effective upon receipt.

3. AOP-21 contains only factual information. Changes to these are not subject to the ratification procedures; they will be promulgated on receipt from the nations concerned.

A. GRØNHEIM
Major General, NOAF
Chairman, MAS

NATION	RESERVATIONS

RECORD OF AMENDMENTS

Change Date	Date entered	Effective Date	By Whom Entered

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FUZING SYSTEMS: MANUAL OF DEVELOPMENT CHARACTERIZATION AND SAFETY TEST METHODS AND PROCEDURES FOR LEAD AND BOOSTER EXPLOSIVE COMPONENTS

AIM

1. The aim of this AOP is to support STANAG 4363 and to provide relevant safety data and a basis for fuzing system safety through the adoption of development characterization and safety tests on lead and booster explosive components.

GUIDANCE

2. This AOP is concerned with the development tests and procedures used by NATO nations to assess the safety and suitability of lead and booster explosive components for use in fuzing systems. It is not a substitute for legislation and regulatory requirements relating to the manufacture, transportation, storage and disposal of these components within the NATO countries.

APPLICATIONS

3. This AOP describes the test procedures and test item configuration and states the information required before and after testing, required test conditions and acceptance criteria for development testing of lead and booster explosive components used in fuzing systems.

GENERAL

4. General Conditions. Lead and booster explosive components for use in fuzing systems, in either an interrupted or non-interrupted explosive train, shall satisfy the following conditions:

a. The explosive compositions shall have been qualified in accordance with the requirements of STANAG 4170 and AOP-7.

b. The shock sensitiveness of the explosive compositions shall be evaluated at or below their specified pressing density.

c. The explosive components shall be compatible with other materials used in these explosive components. The compatibility statements for these explosive components shall be reported in accordance with the instructions specified in paragraph 11 of STANAG 4363.

5. Explosive Component Criteria

a. The explosive components shall pass the applicable safety and characterization tests specified in Annex A of this AOP. However, where procedures for specific tests have not been promulgated in STANAGs, national test procedures may be used.

b. The development test requirements specified in Annex A define the tests that are applicable to the characterization and safety assessment of these explosive components. For these tests to provide useful information on the safety and performance of explosive components, it is essential that detailed specifications of the component and explosive filling are made available from the design authority concerned.

c. The shock sensitiveness of the components should not be adversely affected by the environmental tests specified in Annex A.

6. Development Tests. The components provided for these tests should be manufactured to approved (frozen) drawings and taken randomly from a batch which has been made as close as possible to the final production standard. If the explosive component specifications incorporate changes which are considered to affect safety, then these explosive components shall be re-tested.

7. Safety Tests. Safety tests are conducted to demonstrate that the safety of lead and booster explosive components is established for use in the intended application. The safety of these components within a fuzing system depends principally on their thermal stability and sensitiveness to shock stimuli.

a. Thermal Stability. The requirement to satisfy thermal stability is addressed when the lead or booster explosive component is incorporated in its respective fuzing system or munition, and testing is conducted at the system level.

b. Shock Sensitiveness. The Explosive Component Water Gap Test (ECWGT) is a suitable test procedure for evaluating the shock sensitiveness of a filled lead or booster explosive component not exceeding 15 mm in diameter.
The test results represent the effects of confinement and pressing density of the explosive loading. To ensure that the shock sensitiveness of the explosive component has not been adversely affected by environmental pre-stressing, the ECWGT should be conducted on further components as specified in Annex A. The shock sensitiveness of components with diameters greater than 15 mm may be assessed by conducting a Gap Test in accordance with AOP-7 on the explosive material provided that the material has been manufactured to the same pressing density. In addition a Mechanical Shock or Shielded Impact Test should be conducted.

8. Characterization Test. This test (see Annex A, paragraph 3) should be conducted to confirm the applicability of the lead or booster explosive component for its intended role within a fuzing system.

9. Test Tolerances. The maximum allowable tolerance to test conditions (exclusive of instrument accuracy), unless otherwise specified in any of the tests in this AOP, shall be as follows:

a. Temperature: ± 3°C.

b. Acceleration: ± 20%

10. Accuracy of Test Equipment. The accuracy of the test equipment used in safety and characterization testing of explosive components used in fuzing systems should be as follows:

a. Have an accuracy of at least one-third of the tolerance for the variable to be measured. If this figure conflicts with an accuracy requirement in any one of the tests specified in this AOP, then the accuracy requirement of the test concerned shall apply.

b. Be appropriate for measuring the conditions concerned.

11. Reporting. Nations which develop lead and booster explosive components shall provide the detailed results of any safety and characterization tests that have been conducted. These results shall be available to other National Safety Approving Authorities when requested as a part of the safety statement required in paragraph 12 of STANAG 4363.

12. Data Sheet. Nations which develop lead and booster explosive components shall, when requested by NATO countries procuring these components, provide a data sheet defining the specific component. The data sheet is to be completed in accordance with the format shown in Annex E and is to include the following information:

a. Nomenclature and dimensions.

b. Identification with respective drawing and specification numbers.

c. A drawing, not necessarily to scale, of the filled explosive component.

d. General background data.

e. Qualification/Assessment status.

f. Material data including specification number.

g. Safety and Characterization Test results/Safety statement.

h. Any remarks including compatibility statement and related report.

An example of a completed data sheet is shown in Appendix 1 to Annex E.

TEST REQUIREMENTS FOR LEADS AND BOOSTER EXPLOSIVE COMPONENTS

1. Safety Tests. A suitable safety test for leads and booster explosive components is the Explosive Component Water Gap Test (ECWGT). The test is also designed to measure, through the medium of water, the shock sensitiveness of those explosive components which have been pre-stressed in either thermal shock or vibration. The test, described in Annex B. is not designed to be conducted on these components which have diameters greater than 15 mm. The results of the pre-stressing tests, described in Annexes C and D, provide evidence that safety of these explosive components is maintained or not unacceptably degraded in the test environments of thermal shock and vibration. The results of a Mechanical Shock or Shielded Impact Test are also required to provide evidence on the safety of these components. The general outline of these safety tests is described below.

   a. Explosive Component Water Gap Test. The test measures the hydrodynamic shock required to initiate and propagate a detonation in the explosive component being tested. The shock sensitiveness of an explosive component (the acceptor) is determined by the height of a column of water (gap) through which the shock output of a standardized HE donor pellet explosive is attenuated and transferred to the acceptor. The results are expressed as a measurement of millimeters of water gap. A more detailed description of the test method is provided in Annex B.

   b. Thermal Shock and Vibration Tests. These environmental tests are defined in Annexes C and D.

   c. Mechanical Shock or Shielded Impact Test. A standardized test apparatus and test procedure for conducting this test has yet to be developed. At present nations which conduct such a test on lead and booster explosive components do so using different test apparatus and test procedures. Where test apparati are unable to simulate required severe accelerations associated with long pulse durations, an analysis of the insensitivity of the explosive composition used in the component shall be conducted to determine the achievable values at which the component should be tested.

2. Supplementary Safety Test. A supplementary safety test that may be required for lead and booster explosive components is an Acceleration or Deceleration Test at Temperature Extremes. This test remains to be developed.

3. Characterization Test. The characterization test that is considered suitable for lead and booster explosive components is the ECWGT. For characterization, the modified Bruceton test results provide the mean value of shock sensitiveness and its standard deviation. The test therefore provides evidence towards determining the applicability of that component to fulfil a particular requirement in the explosive train of a fuzing system.

4. Safety Test Programme of Lead and Booster Explosive Components. The ECWGT is to be conducted to evaluate the "No Go" level of shock sensitiveness. After either the thermal shock or the vibration test, the safety part of the ECWGT must be repeated to confirm whether an unacceptable change to the "No Go" value of the shock sensitiveness has occurred. If after exposure to either of these environments, the measured "No Go" value has exceeded the specified acceptance criteria in paragraph 11 of Annex B, then the explosive component is not safe for use in an unshuttered position in an explosive train.

EXPLOSIVE COMPONENT WATER GAP TEST

BACKGROUND

1. Gap tests are used to assess the sensitiveness of energetic materials to an explosive shock stimulus. The characteristics of explosive materials are changed when contained, pressed or associated with other materials in the explosive component. It is therefore necessary to assess the sensitiveness of the filled lead or booster explosive component.

PURPOSE

2. The shock sensitiveness of a lead or booster explosive component can be used in hazard evaluation by comparing it with an alternative component or to investigate the effects of variation in the type of filling, pressing loads, particle size and confinement or any other changes. The Explosive Component Water Gap Test (ECWGT) is used to assess these effects. The results of the ECWGT can also be used to indicate whether a particular lead or booster explosive component is likely to be suitable in a non-interrupted position in an explosive train for a fuzing system,

LIMITATION

3. The ECWGT described below is not suitable for lead and booster explosive components which have an explosive filled diameter exceeding 15 mm.

TEST DESCRIPTION

4. Samples of the lead or booster explosive component are subjected to a series of selected shockwave stimulus levels which are generated by a standardized explosive donor and attenuated by a column of distilled or de-ionised water. A witness rod is used to assess whether or not the lead or booster explosive component has reacted.

TEST EQUIPMENT

5. The test equipment illustrated in Fig 1, includes the following items:

   a. A 100 mm polymethyl methacrylate (PMMA) tube of internal diameter 21 mm and wall thickness 2 mm.

   b. A 21 mm diameter 10.0 g ± 0.05 g RDX/WAX (95/5) donor pellet pressed to a density of 1.6 ± 0.01 g/cc.

   c. A flat base No. 8 detonator (an example of which is illustrated in Appendix 1).

   d. A centralising Detonator Holder.

   e. Distilled/de-ionised water as the attenuation medium,

   f. An aluminium alloy witness rod (99 % Al min).

   g. Centralising and locating plugs for the witness rod.

All the above items are specified on the test Drwg No: BICT/10-9101 which is attached at Appendix 1.

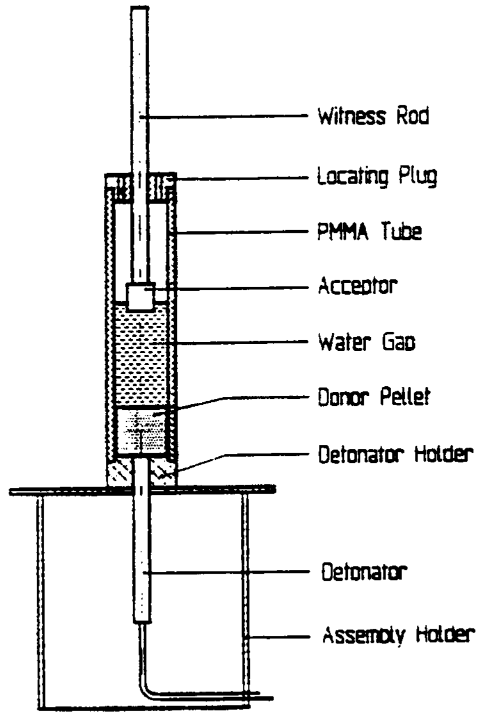


Fig. 1: Explosive Component Water Gap Test (ECWGT)

TEST PROCEDURE

6. Assembly and Firing.

a. Precondition all Test Equipments for 2 hours at 20°C.

b. Locate the donor and the detonator holder (locating plug) at one end of a PMMA tube, and fix with an effective and watertight adhesive, see Fig. 2.1.

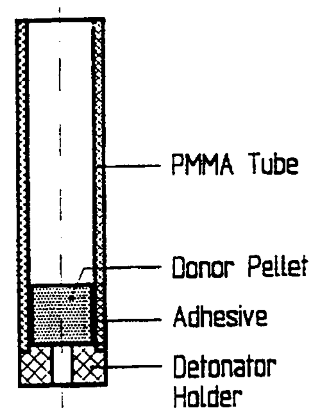


Fig. 2.1: Donor Assembly

c. Attach and centralize the acceptor or explosive component under test to one end of the aluminium witness rod. If the explosive component to be tested has a smaller diameter than that of the witness rod, then the rod diameter should be reduced to the same diameter as the explosive component over a length of 5 mm at the end where the component is to be attached, see Fig. 2.2.

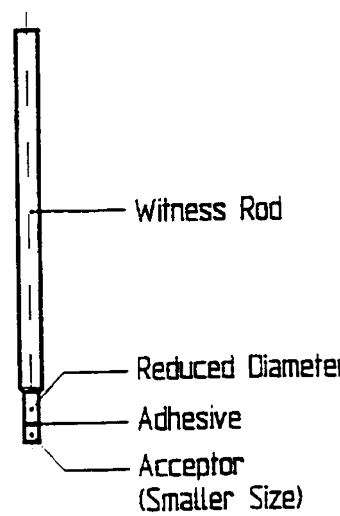


Fig. 2.2: Witness Rod and attached Acceptor Component

d. Fit the witness rod to the centralising and locating guide, and set the selected water gap. The recommended method is to use a gauging piece to set the position of the rod in the locating guide and follow the sequence suggested in Fig. 3.

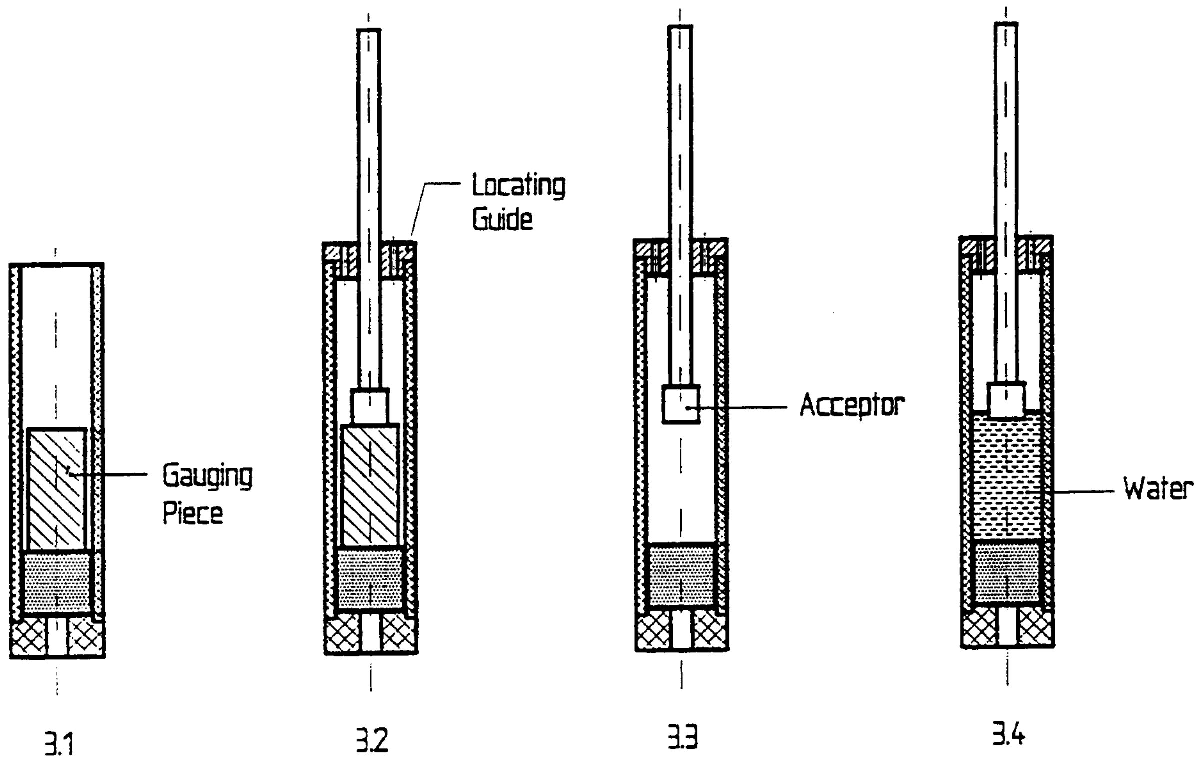


Fig. 3 Recommended Method for Gap Adjustment

e. Add distilled water slowly; via a syringe, through a hole in the guide until the lower surface of the explosive component is immersed to a depth of approximately 1 mm, see Fig. 3.4. Air bubbles at the bottom of the acceptor must be avoided or removed.

f. Position the test assembly as described above in a suitable firing chamber, example see Fig. 4.

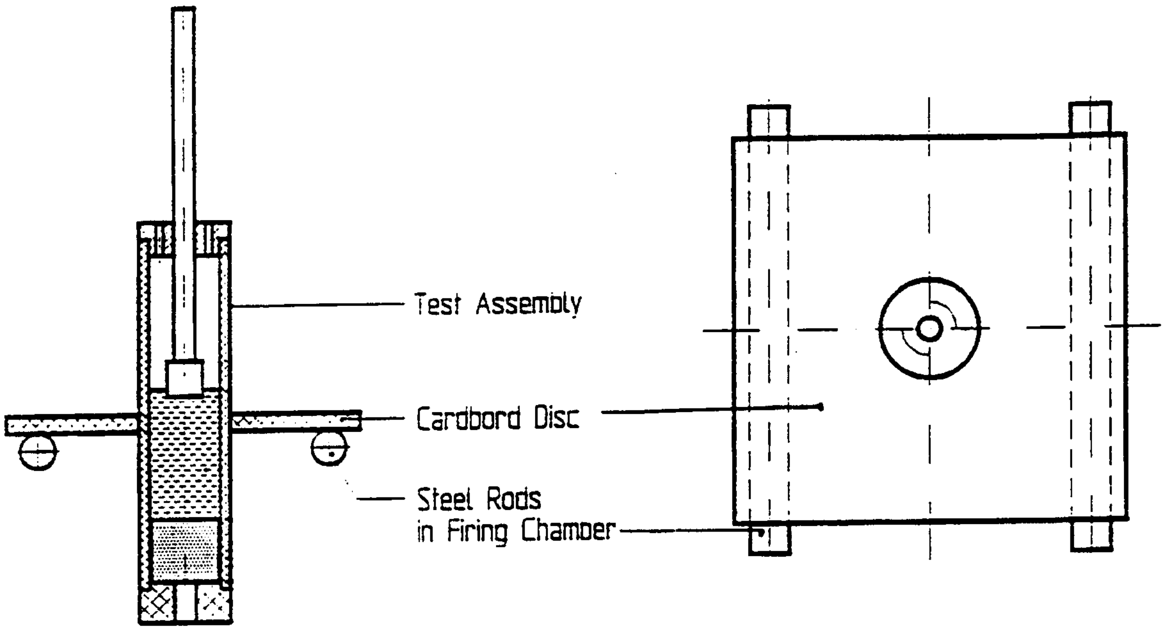


Fig. 4: Example for Positioning the Test Assembly

g. Attach the detonator to the detonator locating plug and then fire the complete assembly.

h. Recover after firing, the aluminium witness rod and any fragments or residue from the explosive component.

i. Record the result either a positive (go) or negative (no-go) event using the data sheet in Appendix 2. A positive explosive event is determined if the end of the aluminium rod which was attached to the acceptor is deformed to such an extent that the diameter is increased by more than 0.3 mm.

7. Test Procedure. When testing the explosive component it should be tested in the orientation which gives the most sensitive test result. This may necessitate some initial testing. The test sequence incorporates a modified Bruceton test up and down stair case procedure which uses a 1 mm water gap increment. The test sequence is conducted as follows:

a. Determine the initial water gap by performing firing tests on the acceptor at water gap levels either side of the anticipated or previously determined median until positive and negative events are obtained.

b. Conduct a test at a scale point approximately midway between the nearest positive and negative results determined in sub-para 7a.

c. Continue testing as described at para b until the difference in the water gap between the nearest positive and negative result is 1 mm.

d. Commence the Bruceton test procedure from one of these levels and continue until 20 trials have been conducted in accordance with the proforma given in Appendix 2. Having conducted this test, the results should be analysed to determine the mean and its standard deviation in accordance with one of the examples given in Appendices 3 and 4.

e. If the sum of the positive events is greater than the sum of negative events, then use the example of the analysis procedure in Appendix 3 (Example A). If the sum of the negative events is greater than or equal to the sum of positive events, then use the analysis procedure in Appendix 4 (Example B).

8. Safety Test Sequence. On completion of the Bruceton test, the no-go water gap level of the explosive component can then be determined using the following method.

a. Identify the water gap (1 mm + maximum gap tested where the result was a positive explosive event).

b. Count the number of results in the Bruceton test at the identified water gap level.

c. If the number of results counted in Para 8b. is less than 5, then conduct further water gap tests at this value until a total of 5 negative events without any positive response is recorded.

d. If during these additional tests a positive result is obtained, then the water gap level is increased by 1 mm and the process is repeated.

e. The test is terminated, when at a selected gap 5 results without any positive event are recorded. This defines the "no-go level".

TEST EVALUATION

9. The Bruceton test results are analysed to give the median water gap and the associated estimate of the standard deviation. The "No Go" level resulting in 0/5 negative responses is noted and the orientation of the tested component is stated. The measured water gap value is converted to the related shock pressure (kbar) using Table 1 in Appendix 5.

TEST DOCUMENTATION

10. Test plans, performance records, equipment conditions, results and analyses must be documented in accordance with the requirements of STANAG 4363 paragraph 12.

SENSITIVENESS CRITERION

11. A lead or booster explosive component shall be considered suitably insensitive to shock to enable its use uninterrupted in explosive trains if its "NO GO" level is less than or equal to 28 mm of water. Additional criteria are specified in Annex A, para 4.

Explosive Component Water Gap Test

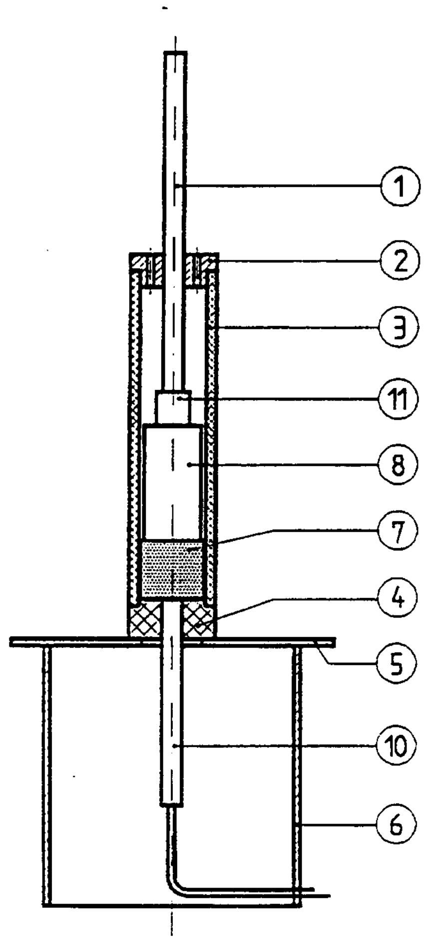
(ECWGT)

BICT-Drawing Set No 10-9101 for Test Equipment

Issue March 1991

Qt.	Designation	Drawing - No.	Pos.	Material	Dimensions (mm)	Remarks
1	Witness Rod	10 - 9101 - 014	1	Al Mg Si Pb	Φ 6 x 100	
1	Locating Plug	10 - 9101 - 024	2	Nylon 66	Φ 25 x 10	
1	PMMA Tube	10 - 9101 - 034	3	Plexiglas XT extruded	Φ 25 x 100	
1	Detonator Holder	10 - 9101 - 044	4	Nylon 66	Φ 25 x 12	
1	Support Disc	10 - 9101 - 054	5	Kraft Paper	Φ 100 x 0.6	
1	Support Tube	10 - 9101 - 064	6	Kraft Paper	Φ 80 x 80	
1	Donor Pellet	10 - 9101 - 074	7	RDX/WAX/Graphite 94.5/4.5/1	Φ 21 x 18	
26	Spacers for Water Gap	10 - 9101 - 084	8	Al	Φ 20 x "X" ("X"= 15,16,17-40)	
1			9			
1	Detonator, el No.8	10 - 9101 - 104	10		Φ 6.9 x 49.5	
1	Acceptor	- -	11		(Test item)	

Change / Data / Name	Data 05.03.91 Name Gulba Provided to Lab. 330	Explosive Component Water Gap Test	10-9101- 4
	Bundesinstitut für chemisch-technische Untersuchungen beim BWB (BICT)	No. of Pages 1	Page No. 1



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		Producer	25.01.	Gulba			
		Approv.					
		Norm.					
		Scale 1 : 2		Material	Model - No. Weight	Delivered to:	No. of Parts
Fit	Tolerance						
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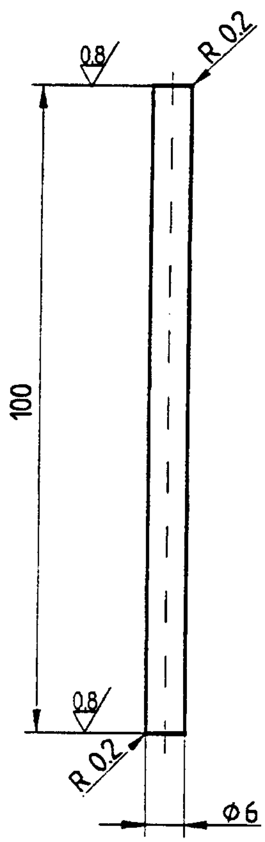

1991	Data	Name	Bundesinstitut für chemisch-technische Untersuchungen beim BWB (BICT)			
Producer	22.02.	Guiba				
Approv.						
Norm.						
Scale 1 : 1			Material Aluminium Alloy BS 1474 6082 (HE 30) TF or Al Mg Si Pb DIN 1725	Model - No. Weight	Delivered to:	No. of Parts
Fil	Tolerance					
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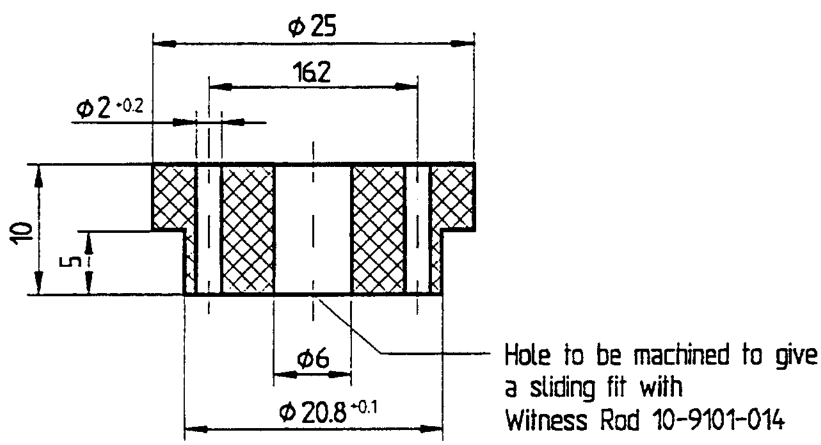

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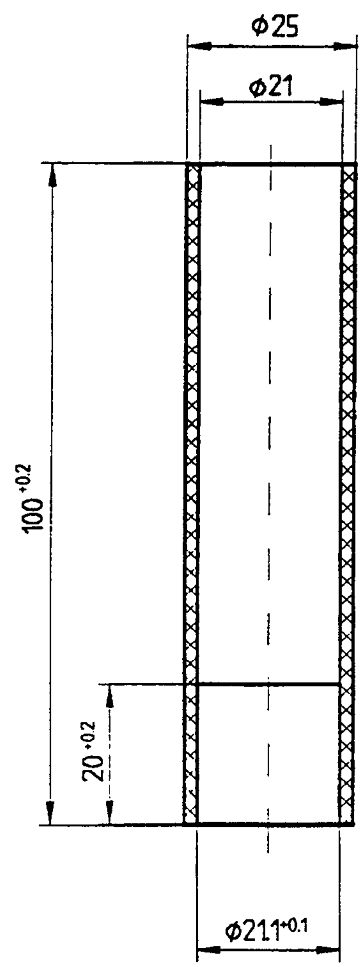
Producer	22.02	Gulba		
Approv.				
Norm.				
Scale 2 : 1		Material Nylon 66	Model - No. Weight	Delivered to:	No. of Parts

Fit	Tolerance
Change	Data / Name

Locating Plug

10-9101-024



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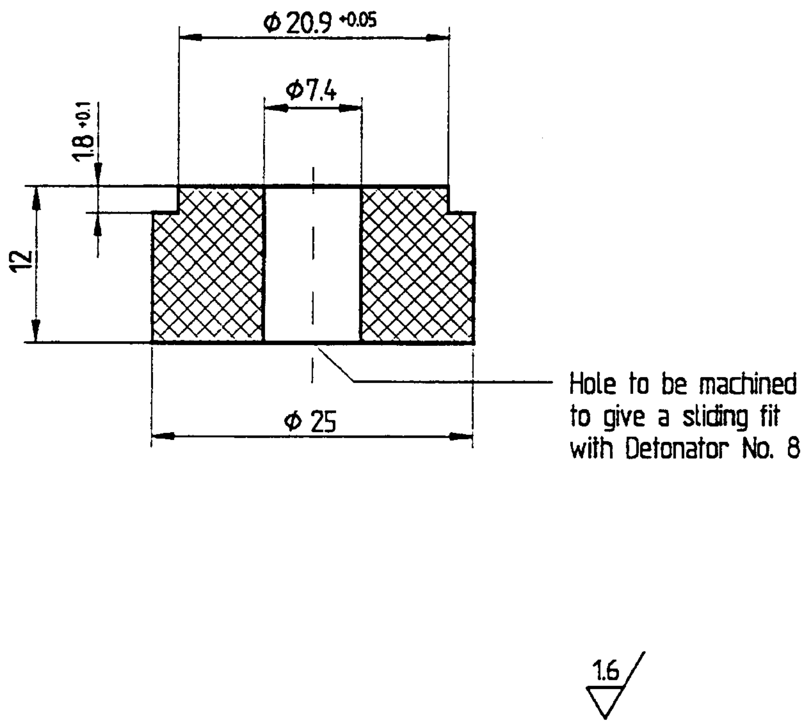
		Approv.					
		Norm.					
		Scale 1 : 1			Material Acrylic Extruded Tube or Plexiglas XT, extruded	Model - No. Weight	Delivered to:	No. of Parts
Fit	Tolerance						
		PMMA Tube			10-9101-034		
Change	Data Name						



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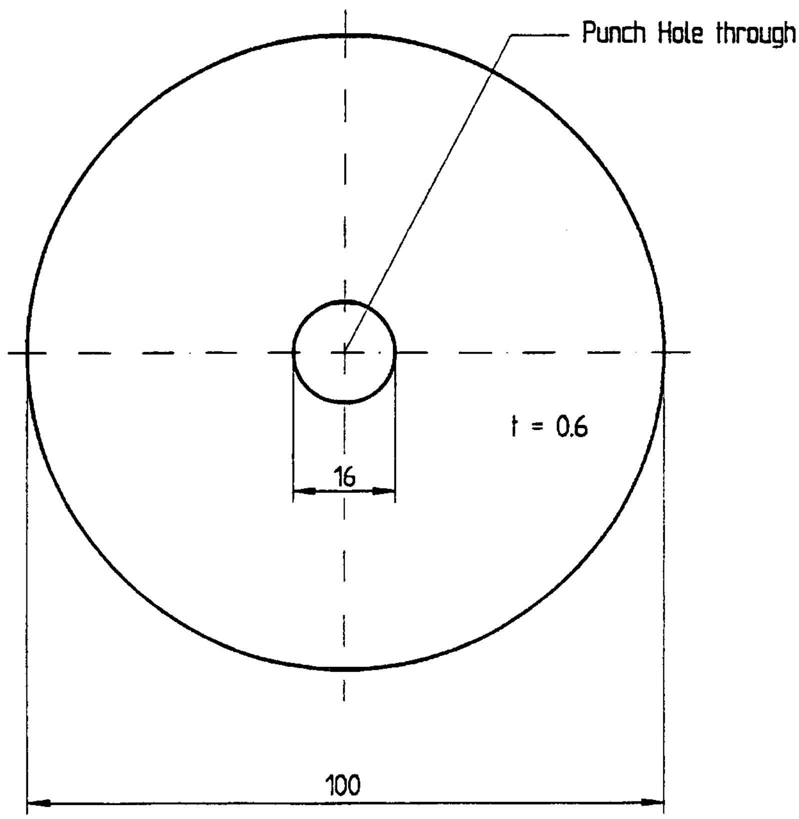
Approv.						
Norm.						
Scale			Material	Model - No. Weight	Delivered to:	No. of Parts
2 : 1			Nylon 66			
Fit	Tolerance					
Change	Data	Name	Detonator Holder	10-9101-044		



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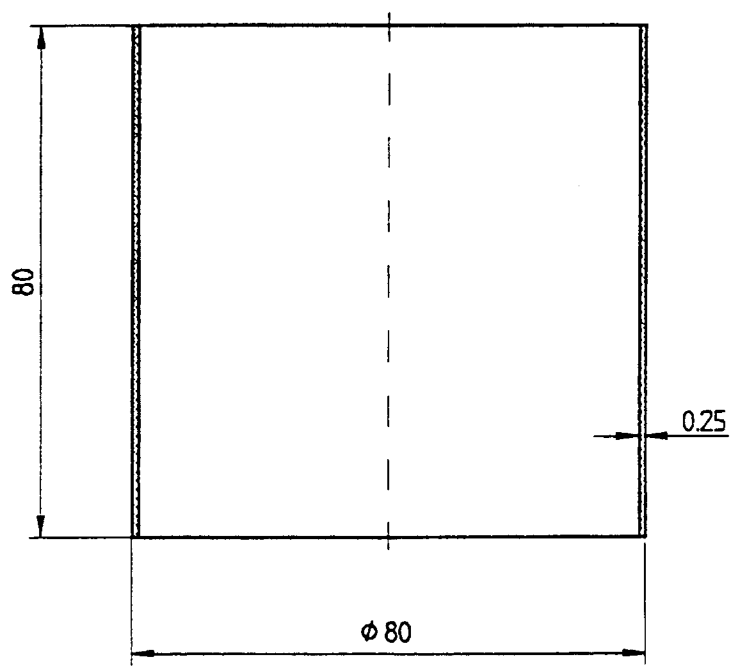
Producer	22.02.	Gulba			
Approv.					
Norm.					
Scale 1 : 1			Material Smooth Unbleached Kraft Paper e.g. DEF STAN 86 A Thickness ca. 0.6 mm	Model - No. Weight	Delivered to:	No. of Parts
Fit	Tolerance				
Change	Data	Name	Support Disc	10-9101-054	



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Producer	25.02.	Gulba	
Approv.			
Norm.			

Fit	Tolerance	Scale		Material	Model - No. Weight	Delivered to:	No. of Parts
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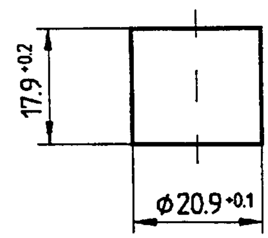
Change	Data	Name		
			Support Tube	10-9101-064



Pressing Density 1.59 - 1.61 gcm^{-3}

1991	Data	Name	Bundesinstitut für chemisch-technische Untersuchungen beim BWB (BICT)		
Producer	25.02.	Gulba			
Approv.					
Norm.					
Scale 1 : 1		Material RDX/WAX 5 % - DEBRIX 2 or RDX/WAX/GRAPHITE 94.5/4.5/1	Model - No. Weight 10.0 g	Delivered to:	No. of Parts
Fit	Tolerance				
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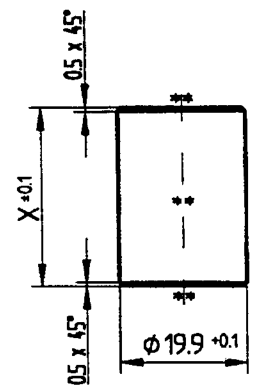

PROTECTIVE FINISH
ANODIZING TO SPEC DEF STAN 03-24
(CHROMIC ACID PROCESS)

Length X	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Number of	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

MARKING NOTE :

BEFORE ANODIZING STAMP OR ETCH IN APROX 5mm NUMERALS
LENGTH X WHERE SHOWN ** THUS.

1991	Data	Name	
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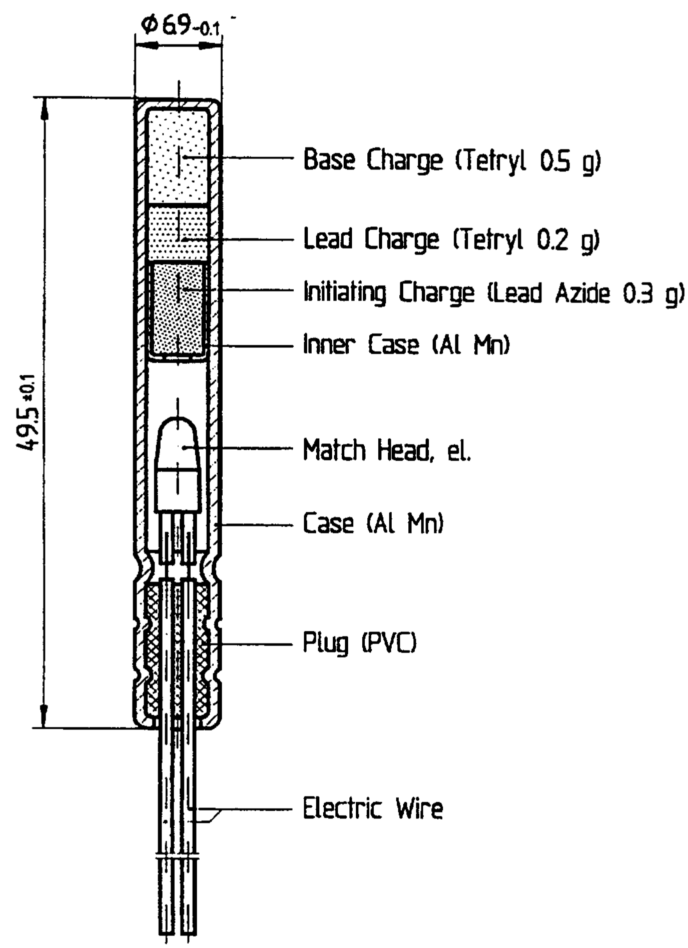
Approv.			
Norm.			

Fit	Tolerance	Scale	Material	Model - No. Weight	Delivered to:	No. of Parts
		1 : 1	Aluminium Alloy BS 1474 6082 (HE 30) TF			

Change	Data	Name		
			Spacers	10-9101-084



1991	Data	Name	Bundesinstitut für chemisch-technische Untersuchungen beim BWB (BICT)		
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Approv.					
Norm.					
Scale 2 : 1			Material	Model - No. Weight	Delivered to:	No. of Parts
Fit	Tolerance				
Change	Data	Name	Example for Detonator, el. No. 8	10-9101-104	

Explosive Component Water Gap Test (ECWGT) Data Form

Results

Explosive Component (EC) : EC Data sheet No. :

Lot No. : Manufacturer :

Explosive Filling : Filling Weight : Loading Density : gcm^{-3}

Acceptor Orientation :

Legend : - = no Reaction, x = Explosion

	Characterization - Test																				Safety - Test				
Water Gap* \ Trial No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
H_1 = mm																									
H_2 = mm																									
H_3 = mm																									
H_4 = mm																									
H_5 = mm																									
H_6 = mm																									

* H_1 = minimum water gap

Calculation

Median $M_{50} = H_1 + \frac{A}{N} \pm 0.5$ ** Drawing :

Standard Deviation $S = 0.05 + 1.6\ \frac{(N \cdot B - A^2)}{N^2}$

** when used N^+ add the value of 0.5
when used N^- subtract the value of 0.5

H (mm)	i	n +	n -	$i \cdot n^{\pm}$	$i^2 \cdot n^{\pm}$
	0			0	0
	1				
	2				
	3				
	4				
	5				
Σ		N^+=	N^-=	A =	B =

from N^+ and N^- use the lower value

Median : mm Water Gap, equivalent to a pressure of approximately kbar

Standard Deviation : mm Water Gap

Explosive Component Water Gap Test (ECWGT)

Explosive Component (EC) : Round Robin Booster EC Data sheet No. : ⊕

Lot No. : ⊕ Manufacturer : Dynamit Nobel AG, Troisdorf

Explosive Filling : PETN Filling Weight : 0,415 g Loading Density : 1,62 gcm^{-3}

Acceptor Orientation : Bottom of case in contact with water gap

Legend : – = no Reaction, x = Explosion

	Characterization - Test																				Safety - Test				
Water Gap* / Trial No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
H_0 = 32 mm														X											
H_1 = 33 mm	X		X				X		X		X		–		X		X		X						
H_2 = 34 mm		–		X		–		–		–		–				–		–		X					
H_3 = 35 mm					–																–	–	–	–	
H_4 = mm																									
H_5 = mm																									

* H_0 = minimum water gap

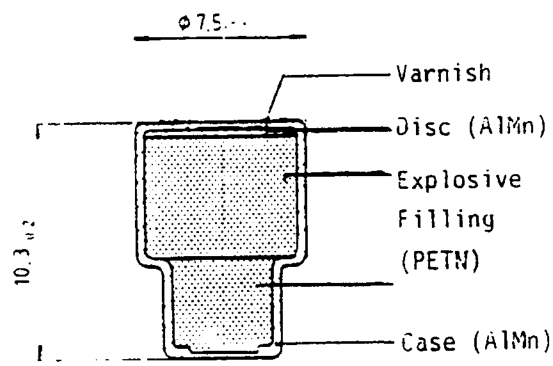
Calculation

H (mm)	i	n +	n -	$i \cdot n^{\pm}$	$i^2 \cdot n^{\pm}$
32	0	1	0	0	0
33	1	8	1	1	1
34	2	2	7	14	28
35	3	0	1	3	9
	4				
	5				
Σ		N^+= 11	N^-= 9	A = 18	B = 38

if $\Sigma n^+ \leq \Sigma n^-$, use n^+

if $\Sigma n^+ > \Sigma n^-$ use n^-

Drawing :



Median $M_{50} = H_0 + \frac{A}{N} \pm 0.5$ ** $M_{50} = 32 + \frac{18}{9} - 0,5$

Standard Deviation $S = 0.05 + 1.6 \frac{(N \cdot B - A^2)}{N^2}$

** if using N^+ add the value of 0.5
if using N^- subtract the value of 0.5

$S = 0,05 + 1,6 \quad \frac{342 - 324}{81}$

Median : 33,5 mm Water Gap, equivalent to a pressure of approximately 7 kbar

Standard Deviation : 0,41 mm Water Gap

Explosive Component Water Gap Test (ECWGT)

Explosive Component (EC) : Zündverstärker (Booster) DM 1415 **EC Data sheet No.** : 130 1053 (17.02.1989)

Lot No. : T-1-3 **Manufacturer** : Dynamit Nobel AG Troisdorf

Explosive Filling : SS C 8042 (Tetryl) **Filling Weight** : 3,15 g **Loading Density** : 1,58 gcm^{-3}

Acceptor Orientation : Bottom of case in contact with water gap

Legend : - = no Reaction, x = Explosion

	Characterization - Test																				Safety - Test				
Water Gap* \ Trial No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
H_0 = 22 mm															X				X						
H_1 = 23 mm		X				X		X		X		X		-		X		-		-					
H_2 = 24 mm	-		X		-		-		-		-		-				-								
H_3 = 25 mm				-																	-	-	-	-	
H_4 = mm																									
H_5 = mm																									

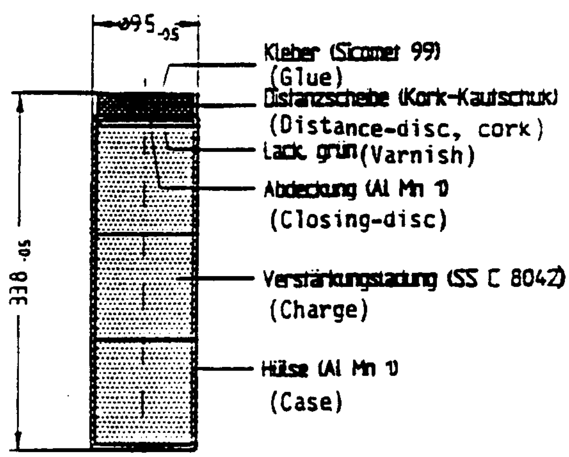
* H_0 = minimum water gap

Calculation

H (mm)	i	n +	n -	$i \cdot n^{\pm}$	$i^2 \cdot n^{\pm}$
22	0	2	0	0	0
23	1	6	3	6	5
24	2	1	7	2	4
25	3	0	1	-	-
	4				
	5				
Σ		N^+ = 9	N^- = 11	A = 8	B = 10

if $\Sigma n^+ \leq \Sigma n^-$, use n^+
if $\Sigma n^+ > \Sigma n^-$, use n^-

Drawing :



Median $M_{50} = H_0 + \frac{A}{N} \pm 0.5$ ** $M_{50} = 22 + \frac{8}{9} + 0,5$

Standard Deviation $S = 0.05 + 1.6 \frac{(N \cdot B - A^2)}{N^2}$

** if using N^+ add the value of 0.5
if using N^- subtract the value of 0.5

$S = 0,05 + 1,6 \frac{90 - 64}{81}$

Median : 23,4 mm Water Gap, equivalent to a pressure of approximately 15 kbar

Standard Deviation : 0,56 mm Water Gap

Table 1

ECWGT RESULTS CONVERSION TO SHOCK PRESSURE VALUES

(Extracted from BICT Report No: 2,3-3/4681/78)

Water Gap (mm)	Shock Pressure (kbar)	Water Gap (mm)	Shock Pressure (kbar)
15	26.0	33	7.2
16	24.1	34	6.7
17	22.4	35	6.2
18	20.9	36	5.8
19	19.6	37	5.4
20	18.4	38	5.0
21	17.2	39	4.7
22	16.2	40	4.4
23	15.2	41	4.1
24	14.3	42	3.8
25	13.3	43	3.
26	12.4	44	3.3
27	11.5	45	3.1
28	10.7	46	2.9
29	9.9	47	2.7
30	9.1	48	2.5
31	8.4	49	2.4
32	7.8	50	2.2

THERMAL SHOCK TEST FOR LEAD AND BOOSTER EXPLOSIVE COMPONENTS IN FUZING SYSTEMS

BACKGROUND

1. Lead and booster explosive components used in fuzing systems may be subjected during their service life to both severe and abrupt temperature changes. The effects of these temperature variations due to different coefficients of thermal expansion of the case materials and explosive loading can cause cracks or brittleness of the pelletized lead or booster and adversely affect the sensitiveness of the component. The assessment of sensitiveness of lead and booster components is a pre-requisite for the integral safety of their related fuzing system and will determine the necessity for an interrupter between either the lead or booster and the charge in a munition. These possible changes in the component explosive pellet structure would not be detected in the complete fuze assembly Thermal Shock Test, conducted in accordance with STANAG 4157 Annex A 1.7. because this test is not sufficiently severe and the leak test criterion for passing the test is irrelevant. There is therefore a need to specify a Thermal Shock Test for lead and booster explosive components.

PURPOSE

2. The purpose of the Thermal Shock Test for lead and booster explosive components is to assess whether temperature changes during the service life of the assembled component will affect the safety of its related fuzing system.

TEST DESCRIPTION

3. The test consists of subjecting lead or booster components to at least 25 cycles of thermal shocks between the temperature extremes of 71°C and -46°C. Less adverse temperature extremes determined from the manufacture-to-target sequence may be used, but should be agreed by the National Safety Approving Authority (NSAA). After completing the thermal shock phase of the test, the samples are subjected to the safety part of the ECWGT (see Annex B) to determine whether the shock sensitiveness has been adversely affected.

TEST EQUIPMENT

4. The test equipment used for this test may be either manual or automatic.

   a. Automatic. The automatic test equipment consists of a thermal shock apparatus containing two independent test chambers and a lift system to transfer the samples from one chamber to the other. The upper chamber should be heated to the high temperature and the lower chamber should be maintained at the low temperature. Each chamber shall be equipped with a fan to circulate the air. The predetermined conditioning time for the samples in each of the test chambers and transfer from one chamber to the other is achieved by programming the equipment and automatic operation of the lift system.

   b. Manual. The manual test equipment consists of two adjacent test chambers. To minimize possible temperature increases when the samples are transferred from the cold chamber, the cold chamber should be equipped with a door on the top. Both chambers shall incorporate a fan for air circulation.

PROCEDURE

5. Automatic. For the automatic test equipment the apparatus shall be checked initially for satisfactory operation and correct storage temperatures. The test is then conducted as follows:

a. Place at least 5 components in the hot test chamber at the high temperature.

b. Set the cold test chamber to the low temperature.

c. Programme the equipment to ensure that during each temperature sequence the components remain in the test chamber for at least 60 minutes at the pre-set temperature.

d. Commence the test sequence with the components initially in the hot chamber.

e. Subject the components 50 times to the high and low temperature regimes in their respective test chambers.

6. Manual. For the manual test equipment, the two test chambers shall be maintained at the extremes of temperature as specified in the automatic test procedure paras 5a and 5b. The test will require several days to complete and shall be conducted as follows:

TEST EQUIPMENT

4. The test equipment used for this test may be either manual or automatic.

a. Automatic. The automatic test equipment consists of a thermal shock apparatus containing two independent test chambers and a lift system to transfer the samples from one chamber to the other. The upper chamber should be heated to the high temperature and the lower chamber should be maintained at the low temperature. Each chamber shall be equipped with a fan to circulate the air. The predetermined conditioning time for the samples in each of the test chambers and transfer from one chamber to the other is achieved by programming the equipment and automatic operation of the lift system.

b. Manual. The manual test equipment consists of two adjacent test chambers. To minimize possible temperature increases when the samples are transferred from the cold chamber, the cold chamber should be equipped with a door on the top. Both chambers shall incorporate a fan for air circulation.

PROCEDURE

5. Automatic. For the automatic test equipment. the apparatus shall be checked initially for satisfactory operation and correct storage temperatures. The test is then conducted as follows:

a. Place at least 5 components in the hot test chamber at the high temperature.

b. Set the cold test chamber to the low temperature.

c. Programme the equipment to ensure that during each

temperature sequence the components remain in the test chamber for at least 60 minutes at the pre-set temperature.

d. Commence the test sequence with the components initially in the hot chamber.

e. Subject the components 50 times to the high and low temperature regimes in their respective test chambers.

6. Manual. For the manual test equipment, the two test chambers shall be maintained at the extremes of temperature as specified in the automatic test procedure paras 5a and 5b. The test will require several days to complete and shall be conducted as follows:

a. Place the components into the hot chamber on a small table of low heat capacity.

b. Remove the table and components after a minimum of 60 minutes and transfer them into the cold chamber as quickly as possible via the door in the top of the cold chamber.

c. Transfer the table and components from the cold chamber to the hot chamber after a minimum of 60 minutes and repeat the process in paras 6a and 6b until 50 cycles are completed.

7. Overnight and Breaks in the Manual Test Procedure. During overnight operations. storage should be arranged for the components to ensure that the overnight temperature is maintained at the temperature at which the test was interrupted. For successive nights, the storage temperature should be maintained alternately hot or cold depending on the previous overnight storage temperature. At breaks in the sequence of more than one night the components should be stored at ambient temperature. On recommencing the test after such a break, the components should be replaced again for at least 60 minutes in the chamber at the temperature prior to the break in the sequence.

TEST EVALUATION

8. The components shall not function when subjected to the ECWGT safety test at the previously determined "No GO" level. If a positive result is obtained at the previously determined "No Go" level, then a complete ECWGT re-evaluation shall be required. In such an event the ECWGT shall be repeated using components subjected to the Thermal Shock Test.

TEST DOCUMENTATION

9. Test procedure equipment conditions, ECWGT-results and post test assessment shall be documented in accordance with the requirements of STANAG 4363, para 12.

SAFETY CRITERIA

10. The criteria are that the components shall meet the safety requirements in Annex A, para 4 and Annex C, para 8.

VIBRATION TEST FOR LEAD AND BOOSTER EXPLOSIVE COMPONENTS IN FUZING SYSTEMS

BACKGROUND

1. Lead and booster explosive components used in fuzing systems may be subjected during their service life to temperature effects and mechanical stressing. These effects can cause changes in the structure of the explosive filling with the result that the sensitiveness of the component could be adversely changed. The assessment of sensitiveness of lead and booster components is a pre-requisite for the integral safety of their related fuzing system and will determine the necessity for an interrupter between either the lead or booster and the charge in a munition. These possible changes in the structure of the explosive component filling would not be detected in the Vibration Test of the complete fuze assembly, conducted in accordance with STANAG 4157, Annex A 1.4, because the components are not broken down, inspected or tested. Also in conducting the test an inert booster may be substituted at the discretion of the design engineer. There is therefore a need to specify a Vibration Test for lead and booster explosive components.

PURPOSE

2. The purpose of this Vibration Test is to determine whether lead and booster explosive components remain acceptably insensitive after being subjected to severe vibration at temperature extremes which may be encountered during carriage and transport.

TEST DESCRIPTION

3. The test consists of subjecting lead or booster components which have been firmly fixed into an adapter in 2 or more orthogonal orientations to a vibration environment of specified frequencies, amplitudes and durations. The components shall undergo the vibration at temperature extremes of 71°C and -46°C. Less adverse temperature extremes determined from the manufacture-to-target sequence may be used, but should be agreed by the National Safety Approving Authority (NSAA). After completing the vibration phase of the test the components are subjected to the safety test part of the ECWGT (See Annex B) to determine whether the shock sensitiveness of the components has been adversely affected.

TEST EQUIPMENT

4. The vibration equipment required to conduct this test shall be any vibration machine which produces rectilinear harmonic motion. The equipment shall be capable of vibrating the components in the frequency range specified in Table 1. The components shall be mounted in the vibration machine by means of an adapter with 6 appropriate holes which simulate the fitting of the lead or booster in its related fuzing system. For threaded components, the bores of these holes should be threaded. When unthreaded components are to be tested the method of retention shall be similar to that which is used in their related fuzing systems.

PROCEDURE

5. Before commencing the test procedure the equipment shall be checked for satisfactory operation and correct temperature conditions. The test is then conducted as follows:

a. Pre-condition at least 6 components for a minimum of 4 hours at each of the high and low temperature extremes.

b. Mount the components into the adapter in the following orientations:

(1) In the longitudinal axis.

(2) Perpendicular to the longitudinal axis.

(3) In 3 orthogonal axes if the component is not radially symmetrical.

c. Vibrate the components in the above orientations for 4 hours in each orientation at the temperature extremes.

d. Sweep logarithmically the frequency of vibration from 5 to 500 to 5 Hz in 60 minutes using the test levels of Table 1 with the following levels of accuracy:

(1) Sweeptime ± 3 %.

(2) Frequency ± 1 Hz from 5 to 50 Hz and ± 2 % from 50 to 500 Hz.

Table I

Frequency Range	Test Level
5 - 14 Hz	12 mm Double Amplitude Displacement ± 10 %
14 - 500 Hz	5 0 m/s^2 ± 10 %

TEST EVALUATION

6. After completing the vibration phase of the test the components shall be examined to confirm the integrity of the components and then subjected to the ECWGT. The components shall not function when subjected to the ECWGT safety test at the previously determined "No Go" level.
If a positive result is obtained at the previously determined "NO GO" level. then a complete ECWGT re-evaluation shall be required. In such an event the ECWGT shall be repeated using components subjected to the Vibration Test.

TEST DOCUMENTATION

7. Test procedure. equipment conditions. ECWGT results and post test assessment shall be documented in accordance with the requirements of STANAG 4363, para 12.

SAFETY CRITERIA

8. The criteria is that the components shall meet the safety requirements of Annex A, para 4 and Annex D, para 6.

DATA SHEET FORMAT

NAME: Lead or Booster and Number

Dia: -------- (mm)

Length: ------- (mm)

IDENTIFICATION:

Agency:
Country:
Drawing No:
Issue Date:
Specification No:

Producer:
Drawing No:

GENERAL: (Drawing not to scale)

In Service Date:
Replaces:
Previous Drwg No:
Used in:

QUALIFICATION/ASSESSMENT REPORT:

Lot No:
National Safety Approving Authority Report No:

MATERIALS:

Explosives	wt	Spec No

Non-Explosives	wt	Spec No

SAFETY & CHARACTERIZATION TEST RESULTS:

SAFETY STATEMENT: Meets the Requirements of STANAG 4363: Yes/No
REMARKS:

EXAMPLE OF A COMPLETED DATA SHEET

NOMEN:	LEAD DM 1015 Bl	:
Dia:	5,05 mm	:
Length:	10,8 mm	:
IDENTIFICATION:		:
Agency:	BWB WM II 4	:
Country:	GE	:
Drawing No:	1300 632	:
Issue Date:	Nov. 81	:
Specific.No:	TL 1375-1300	:
Producer:	DNAG	:
Drawing No:	M 1088	:

GENERAL:

In Service Date: 1973
Replaces: Lead DM 1015
Previous Drwg No.: 13 02 03
Used in: AZZ DM 111

QUALIFICATION/ASSESSMENT REPORT
Lot No.:
not required in 1973

(Drawing not to scale)

MATERIALS:	(Explosives)		(wt)	(Spec.No.)
	Tetryl SS C 8041,		>195 mg,	TL 1376-0804
	Tetryl SS C 8043,		> 25 mg,	TL 1376-0804
	(Non Explosives)		(wt)	(Spec.No.)
Cup:	AlMn	SPEC.:	DIN 1725	Cover-Disc:Paper
Laquer:	none			

SAFETY & CHARACTERISTICS DATA:

ECWGT: 27 mm Water 5 times no Detonation (BICT Report 3.4-9/5694/81, Detonator safety investigation for fuze train of AZZ DM 111 A3)

SAFETY STATEMENT: Meets the Requirements of STANAG 4363: Yes/No.

REMARKS:

Compatibility Report No.: not available (Materials are known as compatible according to results from former investigations)

Confirmation of shock sensitivity by Explosive Component Water Gap Test is required for each production lot.